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THE AMERICAN

METEOROLOGICAL JOURNAL

VOL. VIII. ANN ARBOR, MICH., MARCH, 1892. No 11.

ORIGINAL ARTICLES.

NEW ENGLAND METEOROLOGICAL SOCIETY.

The twenty-third regular meeting was held in Boston, January 23, 1892, when the following papers were read upon the measurement of the vertical air currents and upon the artificial production of rain.

The order of the papers is as follows:—

Mr. S. P. Fergusson's discussion of an Anemograph for measuring vertical currents in use at Blue Hill Observatory.

The subject of Artificial Production of Rain as presented in papers by Mr. R. De C. Ward, "Artificial Rain—a Review of the Subject to the Close of 1889;" Prof. W. M. Davis, "The Theories of Artificial and Natural Rainfall;" and Mr. George E. Curtis, of Washington, D. C., "The Recent Experiments in Artificial Rain." (The latter paper is not here printed).

THE ANEMOGRAPH FOR VERTICAL CURRENTS AT THE BLUE HILL OBSERVATORY.

BY S. P. FERGUSSON.

The anemograph for measuring vertical motions of the air was invented by Rev. Fr. Dechevrens, at that time director of the Zi-ka-wei Observatory, but some modifications have been introduced in the present form of the instrument constructed

by Richard Bros., of Paris, which was set up at the Blue Hill Observatory in October, 1891.

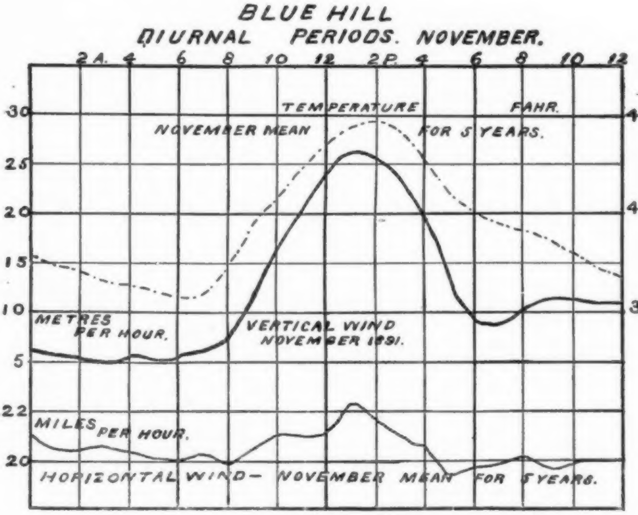
The motor turned by the wind is a wheel having four blades, or fans, fixed at an angle of 45° to its axis, which, when the instrument is in use is placed vertically. While in this position the wheel is not affected by horizontal currents, but is moved in one direction by ascending and in the opposite by descending currents. The wheel revolves once for each two metres of wind, and makes three electric contacts during a revolution, each of which is connected with an electro-magnet of the recording apparatus. The electro-magnets are arranged symmetrically around a crown-wheel having four teeth, and as the contacts in the anemometer are made in succession, the armatures of the electro-magnets turn the crown-wheel in the same direction in which the anemometer wheel is turned by the wind. The crown-wheel is connected with the record cylinder which turns once for each thousand metres. The motor is exposed on an iron pole thirty feet above the observatory tower and fifty-one feet above the ground.

Compared with the horizontal movement of the wind, the vertical movements recorded at Blue Hill are very small, averaging only about 300 metres daily. These currents are not steady, but seem to move in pulses or waves, the anemometer wheel sometimes revolving at the rate of four or five metres a second for a time, then oscillating backward and forward a few minutes or making a few turns backward. Very few descending winds of more than ten metres a day have yet been recorded, though ascending winds are recorded daily. It is likely that this great excess of ascending currents is partially caused by the upward deflection of the horizontal wind by the sides of the hill, also it has been suggested that the descending currents are steadier than the ascending, and consequently have less effect on the anemometer.

The accompanying figure shows the diurnal period of the vertical component of the wind during November, 1891, compared with the normal diurnal periods of the horizontal component, and of the air temperature. The maxima and minima of all the curves occur near together, but special cases have shown that the variations of the vertical component follow those of the air temperature more closely than any other

element. On cloudy days when the range of temperature is small the vertical currents are much weaker than on clear days and the increase in velocity at noon is not so marked. The heating of the sides of the hill by the sun on clear days is probably the cause of this increase in velocity, which occurs frequently when the horizontal velocity is decreasing or has reached a minimum.

The few downward movements recorded have, without exception, occurred with winds varying in direction between north and east, the horizontal movement being very light, or below normal, and the weather cloudy.



When a longer series of records has been obtained the relations of these vertical currents to other elements of the weather will be further investigated, this paper being mainly intended as a description of the instrument and its manner of working. The errors of the anemograph and of its exposure have yet to be determined and corrections applied before accurate results can be obtained, and the results of a few observations given must not be considered final.

ARTIFICIAL RAIN; A REVIEW OF THE SUBJECT TO THE CLOSE OF 1889.

By R. De C. Ward.

The wide-spread interest that has been taken in the artificial rain experiments in Texas during the past summer, not only in the United States but in Europe also, has brought up a very general discussion on the subject in both countries, which is now occupying considerable space in the scientific journals. It is not generally known, however, that the question of causing rain by artificial means is no new one, but has already been noticed by many writers in past years, and a short review of what has been written on the subject may not be an uninteresting introduction to the discussion on the experiments of last summer.

Two causes of artificial rain have been suggested, explosions and fire. The belief that battles occasion rain is older than the invention of gunpowder, for Plutarch, in that sentence so often quoted recently, says: "It is a matter of current observation that extraordinary rains pretty generally fall after great battles," and he explains this by supposing that some divine power in this way cleanses the earth, or that the vapors from the blood steam forth and make moisture fall. Arago ("Thunderstorms") mentions some instances where rains followed cannonading, and draws the conclusion that such explosions operate to gather clouds and cause rain. The belief that fires can cause rain is also a very old one, but Espy first proposed experiments to test it.

As is well known, Espy's great work was on the moisture of the atmosphere, and in connection with the cooling of ascending air and the resulting condensation, he made some observations on the artificial production of rain, which are so striking that it is a wonder no more attention has been paid to them. In 1839, in a letter to the editors of the "*National Gazette*," (reprinted in the *Philosophy of Storms*, 1841) speaking of the fact that air moves inward to regions where a great rain is falling, and, he adds, "of course upwards," it follows, he says, "that if a large body of air is made to ascend in a column, a large cloud will be generated and that that cloud will contain in itself a self-sustaining power, which may move from the place over which it has formed, and cause the air over which it passes to

rise up into it, and thus form cloud and rain, until the rain may become more general; for many storms which commence in the West Indies, very narrow, are known to move from the place of beginning several thousand miles, widening out and increasing in size, until they become many hundred miles wide." This being so, volcanic explosions should produce rain, as they are known to do, and under favorable circumstances, great fires ought also to produce rain. To illustrate the latter point Espy quotes numerous accounts of rain produced by fires. One from a missionary in Paraguay, who says: "I myself have seen clouds and lightning produced from the smoke (from burning grass and bulrushes) as it is flying off like a whirlwind, so that the Indians are not to blame for setting fire to the plains in order to produce rain, they having learned that the smoke turns into clouds which pour forth water." Although Espy scouts the idea that smoke turns into clouds, it is interesting, in connection with Mr. Aitken's recent investigations into the number of dust particles in the atmosphere and their effect on the formation of fog and rain, to notice that he quotes evidence of the formation of clouds over great cities, and of the frequent rains and fogs resulting from them.

The evidence is that the air in ascending, as it must do over a great fire, will cool by diminished pressure, and will condense its vapor into clouds "as soon as it shall rise about as many hundred yards as the temperature of the air is above the dew-point in degrees of Fahr." The reasons why volcanic explosions and great fires do not always produce rain are three in number: First, if there is a current of air of some height it sweeps away the uprushing current of air. Second, the dew-point may be too low to produce rain at all. Third, there may be an upper stratum of air so light that the upmoving column may not be able to rise far enough into it to cause rain. "These three things," says Espy, "I conceive are the only circumstances which prevent great fires from producing rain at all times when they occur. The first two can be ascertained without much difficulty by means of small balloons and the dew-point; the last, in the present state of science, cannot always be known, and a failure on that account must be risked by the experimenter. This risk I am willing to run, if Congress or the State Legislature will promise a sufficient reward in case of success." There being generally more vapor in summer drought than at any other time, "for the vapor is rising into

the air and increasing every day of dry weather, preparing for another rain," it is perfectly possible to make artificial rain in summer. "If I should be encouraged to go on with the experiment," Espy says, in conclusion, "I mean to have a large mass of combustibles prepared ready for use, and when I have found all the circumstances, mentioned before, favorable in the time of drought, I would set fire to the circumference, in various places at once. Soon after the fire commences, I will expect to see clouds begin to form, about as many hundred yards high as the temperature of the air is above the dew point in degrees of Fahr. I will expect to see this cloud rapidly increase in size, if its top is not swept off by the current of air at a considerable distance above the earth, until it becomes so lofty as to rain."

In his first publication on the subject, dated 1839, from which the above extracts are taken, Espy says nothing about the occurrence of rain after great battles, which has been the main point in the recent revival of the artificial rain theory. In the *Philosophy of Storms,* however, he refers, without comment, to the fact that heavy rains, evidently because produced by heat, occurred in connection with the battles of Dresden, Ligny and Eylau, and quotes a case mentioned by Col. Capper ("Monsoons," p. 171) of a rain which occurred at Madras after the firing of a number of salutes during the dry season of 1776. Letters from various persons on the occurrence of rains over forest fires and burning grass in Florida, Kentucky, and in other places are given, and of these one from a correspondent in Virginia must suffice for quotation here. "In the month of August," the writer says, "after a long dry season, it was proposed to set fire to the clearing (ten acres of dry brush), the day was clear; not a cloud to be seen, and was selected for its calmness for fear the fire would damage other property. Well, all hands were called, fire obtained, many of us went to work, the leaves were so dry the brush ignited with great rapidity; in a few moments the whole circle of the clearing was on fire; very soon a strong wind set in from all points of the compass; the smoke and flame assumed an upward gyral motion ('like a whirlwind') a cloud was soon formed and a fine rain fell for some miles around. I was convinced that the rain was produced by that fire."

In his Second Report, published in 1850, Espy gives some further letters which he received regarding the subject of

rain produced over fires. One note is from Cowdersport, Pa., where the burning of a fallow containing six acres on a calm warm day gave rise to a white cloud over the black smoke. Gradually the cloud "rolled outwards above," extending further to the east than to the west, and in less than an hour after the fire started a shower began and lasted half an hour. The phenomenon is vouched for by a clergyman, a judge, a justice of the peace, and two attorneys-at-law. Some extraordinary statements are made of rains produced in Florida by firing grass, much to the terror of the negroes, who could not understand how men could "make clouds out o' nuffin," and it is stated that the farmers were in the habit of setting their grass on fire at the time they planted their corn in order to produce rain. Another correspondent wrote from Keene, N. H., that he went up Monadnock on a fine cloudless day, and from the top saw that a farmer had kindled a fire of brush, away down on the low ground. The smoke rose in a column as straight as an arrow, and presently began to expand at the top and assume the appearance of a cloud, which gradually grew until rain descended from it, the cloud moving away in an easterly direction, "pouring down torrents of rain in its pathway." The whole thing was perfectly visible to the observer from the top of the mountain, and not another cloud appeared in the sky. In concluding his statements on the subject, Espy advises farmers to save their timber and brush until the first dry spell in summer, and then to fire them simultaneously, or in accordance with some definite prearranged plan. In this way he thinks it highly probable that extended rains could be produced, which would be of great benefit to agriculture. "I hope this request will be complied with," he says, "not only because all are interested in the probable result, but because it will be attended with no expense."

In a note to the *National Intelligencer*, July 25, 1861, J. C. Lewis mentions the fact that after the discharge of ordnance in celebration of the completion of the Erie Canal in October, 1825, a copious rain occurred, and also calls attention to the fact that many battles in the (then) late war between the French, Sardinians and Austrians were followed by great rains, as well as some of the earlier battles of our Civil War, which had then just begun. The publication of this statement in *Petermann's Mittheilungen* brought out a report of the occurrence of a rain after the bombardment of Ofen, May 4, 1849, although the sky had been

clear for several weeks previously. In one of the Cincinnati papers, July 10, 1862, the importance of accurately observing the results of the battles of our Civil War is noted, for if the fact could be definitely established, the writer says, that rain can be produced by artificial explosions, the benefit to agriculture might be very great.

Some remarks on artificial rain made before the Geological Section of the British Association in 1870, reopened the subject again after a considerable period of rest, and in *Nature*, Vol, 3, February 16, 1871, Laughton, under the heading "Can Weather be Influenced by Artificial Means?" refers to Espy's statements already quoted, and says: "It is of course difficult to speak with absolute certainty; it may almost always be said that a few drops have fallen, sufficient to bear out the truth of Espy's theory, but it seems to me that to establish it in its entirety something more than this is necessary, and that an extraordinary fire ought to produce a very decided shower, if not a heavy downpour." To show that this is not the case, Laughton gives instances where burning brush in hot dry weather did not result in any rainfall. As regards the effect of explosions he thinks the evidence is also very imperfect, and the fact that several battles and bombardments have been followed by storms is balanced by an equally sure fact that several have not. Laughton sums up his views as follows: "What appears to me the only explanation of the apparent contradictions in the evidence is this: that large fires, explosions, battles and earthquakes, do tend to cause atmospheric disturbance, and, especially, to induce a fall of rain, but for the tendency to produce effect, it is necessary that other conditions should be suitable; that rain does not follow unless the lower air contain a great deal of moisture; and that therefore the ascensional movement does not reach to a height such as we might at first be led to conceive; that in fact the height is for the most part very trifling. With regard to storms said to have been caused by some of these agencies, the evidence is still more unsatisfactory, and in our present ignorance of the cause of storms generally, is quite insufficient to compel us to attribute any one particular gale, extending probably over a wide area to some very limited and comparatively insignificant disturbance."

In 1871 appeared a book which, in its second edition, issued in 1890, was the main factor in bringing about the artificial rain experiments of last summer. Its title is, "War and the

Weather," and as its name implies, it deals with the question of rain as a result of firing in battles. In order to prove his opinion, the author, Mr. Powers, refers to two hundred battles and salutes which were followed by rain, and also to a number of campaigns and sieges during which it was unusually rainy. Apart from the fact that many errors are made in this connection, the author omits some very important links in his chain of evidence. In the first place, he does not state clearly how soon he thinks the rain should come after the battle if it is due to the firing, and also he omits to say whether or not the amount of rain is proportionate to the firing. And secondly, no effort is made to show that the rains following the battles did not begin further to the west and with the general movement of the atmosphere were brought to the battle-field at about the time when the so-called artificial rain fell. In the case of the rains following many battles of our Civil War it is impossible to determine the latter point, for our weather maps were not issued till some years later, but at the time of the Franco-German War of 1870–1871 European weather maps were published, and there is therefore an interesting field for investigation open in this direction. This war was believed to have caused heavy rains in Germany, Frankfort having been especially subject to them, a fact which was generally attributed by the German press to the firing in Alsace-Lorraine.

In *Nature*, Vol. 6, 1872, p. 121, there is an interesting note from a correspondent in New Zealand, who, cautiously saying that he ventures no opinion on this subject, makes mention of several cases of rains occurring in excessively dry weather with strong N. W. or N. E. winds, the district at that time suffering greatly from bush fires. One of his notes reads as follows: "February 16. Strong N. E. Heavy bush fire. Slight showers from the S. W. in the morning; wind veered to N. E." ("N. E. is a cool dry wind from the sea.")

The great fire at Chicago in 1871 aroused new interest in the subject, and it was believed by many persons that that fire was stopped by the rainfall which it caused. A telegram sent to London read as follows: "This fire was chiefly checked on the third or fourth day by the heavy and continuous downpour of rain, which it is conjectured was partly due to the great atmospheric disturbances which such an extensive fire would cause, especially when we are told that the season just previous to the outbreak of the fire had been particularly dry." The other

side of the story is heard in an article published in the *Journal of the Franklin Institute*, July, 1872, by Prof. I. A. Lapham, Assistant to the Chief Signal Officer, U. S. A., who speaks of the burning of Chicago as follows; "During all this time—twenty-four hours of conflagration upon the largest scale—no rain was seen to fall, nor did any rain fall until four o'clock the next morning; and this was not a very considerable downpour, but only a gentle rain, that extended over a large district of country, differing in no respect from the usual rains. It was not until four days afterward that anything like a heavy rain occurred. It is, therefore, quite certain that this case cannot be referred to as an example of the production of rain by a great fire." Prof. Lapham goes on to show that the essential conditions for the production of rain—a calm atmosphere and a high dew-point—were wanting in this case, the air being very dry and the wind blowing a gale. "The case, therefore," the writer says, "neither confirms nor disproves the Espian theory, and we may still believe the well-authenticated cases where, under favorable circumstances of very moist air and absence of wind, rain has been produced by very large fires."

In an article in the *Popular Science Monthly* for December, 1872, Prof. John Trowbridge, of Harvard, gives the results of some experiments which he made on the influence of flames upon the electrical state of the air. He found that the flame he used was negative and tended "by its presence to reduce the positive charge of electricity which generally characterizes the air of fine weather to zero or to change it to a feebly negative charge." The normal condition of the atmosphere is positive, and it has been shown by Sir William Thompson that clearing weather is preceded, and can in many cases be foretold, by a change in the atmosphere from a negative to a positive charge of electricity. Great fires, then, may have an influence on the production of rain by changing the electrical state of the atmosphere. Prof. Trowbridge concludes by saying: "The state of our knowledge, however, in regard to the part that electricity plays in atmospheric changes is very meagre. The question of the truth of the popular belief that great fires are followed by rain still remains unanswered."

In 1880, a man named David Ruggles, of Virginia, took out a patent for what he designated as "a new and useful mode of producing rain or precipitating rainfalls from rainclouds, for the purpose of sustaining vegetation, and for sanitary purposes."

The idea was to send up balloons carrying torpedoes and other explosives, which were to be exploded in the upper air by electric currents. In the words of Mr. Ruggles, (*Scientific American*, Vol. 43, 1880, p. 106.) "I contemplate the employment of nitro-glycerine, dynamite, chlorates of nitrogen, gun-cotton, gunpowder, fulminates and other explosives, and to use the magneto-electric telegraph on the surface of the ground and the phono-telegraph in the cloud-realm to direct action in cases where a regular balloon not charged with explosives is occupied by an æronaut to reconnoiter the cloud-realm, to trail torpedoes and cartridges, or to throw them in parachutes, and to explode or detonate them either from the balloon occupied by the æronant or from the ground." The inventor expected not only to cause rain, but also to prevent excessive rainfall, in the latter case by causing the clouds to discharge their rain before they reached a given locality, and he said: "My invention is based on discoveries in meteorological science, and that electrical force controls the atmospheric realm and governs the movements of the rain-clouds, bursting into thunderstorms, dispensing rain and hail, and into cyclones and tornadoes, illuminated by magneto-electric forces as prime attributes of matter." A balloon scheme, somewhat similar to this, was the one which Gen. Dyrenforth and his associates tried last summer in Texas.

Another rain-controller was suggested in the same year by Mr. G. H. Bell, of New York. This consisted of a tower 1,500 feet high, hollow at the center, and through this space saturated air was to be blown into the upper atmosphere. A system of tubes around the tower was designed to increase the volume of up-rushing air. The inventor says, (*Scientific American*, Vol. 43, 1880, p. 113.) "While these tubes, discreetly located, at meteorological centers, would doubtless become reliable agencies for the formation of clouds, it should be their faculty also to prevent rain; for by reversing the motion of the fan or blower, a descensional flow of air would begin which might annihilate the clouds overhanging, by bringing them to earth in æriform and holding them here until they be wanted in precipitation on some locality, then instituting the ascensional flow and send them up to be condensed. A nation furnished with a reasonable number (of towers) might prove them her wealth and grandeur."

A further interesting contribution to the discussion is the

address delivered in 1884, to the Royal Society, of New South Wales, by Mr. H. C. Russell, the president and Government astronomer. He refers to the old idea that clouds and storms could be dispelled by cannonading, which gave way after 1810, to the opposite view, that such discharges cause rain. He turns next to Espy's idea, that great fires could be used to produce rain, and quotes Prof. Henry's opinion on this question, (*Science*, 3, 1883, p. 220:) "I have great respect for Mr. Espy's scientific character, notwithstanding his aberration, in a practical point of view, as to the economical production of rain. The fact has been abundantly proved by observation, that a large fire sometimes produces an overturn in the unstable equilibrium of the atmosphere and gives rise to the beginning of a violent storm." A review of the records of forty-eight large fires leads Mr. Russell to the conclusion that rain in no case followed within forty-eight hours, as a consequence of the fire. In order to get an additional rainfall of 60 per cent. at Sidney, he calculates that a mass of air over a surface of 52,000 square feet would have to be raised 1,800 feet every minute, and the total amount of coal necessary to do this would be 9,000,000 tons a day. "This serves," Mr. Russell says, "to give some idea of what is necessary to disturb the course of nature, and—shows how utterly futile any such attempt would be, even near the sea, where the air is moist." Mr. Russell concludes that the only chance to make rain would be when a cold current overlies a warm one, i. e., when the air is in a condition of unstable equilibrium.

Mr. Fernow, Chief of the Division of Forestry, in a report to Secretary Rusk concerning the experiments which were to be made in the summer of 1891, says: "The theories in regard to the causes of storms, and especially their local and temporal distribution, are still incomplete and unsatisfactory. It can by no means be claimed that we know all the causes, much less their precise action in precipitation. It would, therefore, be presumptuous to deny any possible effects of explosions; but so far as we now understand the forces and methods in precipitating rain, there seems to be no reasonable ground for the expectation that they will be effective. We may say, then, that at this stage of meteorological knowledge we are not justified in expecting any results from trials as proposed for the production of artificial rainfall, and that it were better to increase this knowledge first by simple laboratory investigations and experiments preliminary to experiment on a larger scale."

It may be stated in conclusion that, admitting that explosions and fires have in some few cases determined rainfall, as seems to be pretty well shown, they can only do so when moisture is present in sufficient quantity in the air, and when the other conditions, such as temperature and wind, are favorable. In other words, when the conditions are favorable for rain, explosions and fires may precipitate the rain, but when the air is too dry, no artificial means can cause rain to fall.

The foregoing summary is not intended to be complete or exhaustive. It is, however, as full as the time and the material at the disposal of the writer would allow, and will, it is hoped, serve to give some general idea of the publications concerning artificial rain up to the close of 1889.

Harvard College, Jan., 1892.

NOTE.—Since preparing the above review the writer has found a few other references on the subject. In the memoirs of Benvenuto Cellini there is mention of the fact that an impending rain storm was averted in the year 1539, on the occasion of a procession in Rome, by his firing off artillery in the direction of the clouds, which had already begun to drop their moisture. In 1867, in a book entitled "Sunshine and Showers," the author, Steinmetz, advocates the use of cannon to bring down rain in seasons of drought, a plan which he says, would no doubt result in producing rainfall and at the same time would give practice to the soldiers. Another book, "Cannons and Tempests," appeared about 1863, also on the same subject.

THE THEORIES OF ARTIFICIAL AND NATURAL RAINFALL.

BY WILLIAM MORRIS DAVIS.

There are millions of acres on our Western plains whose value would be doubled and quadrupled if they were better watered. They would be well worth buying at present low prices if the purchasers were convinced that engineering works might irrigate them economically from rivers or if any methods whatever could be devised for irrigating them cheaply enough from the clouds. Such purchases would be as well warranted as those by which the farms around the falls of the Merrimac were purchased by those far-sighted business men who diverted the water-power from waste on the rocks to use in the mills, and built the great city of Lowell on the river banks.

In the East we do not feel the crying need for water that is felt on the plains. The matter is distant from us. In the West it is a pressing necessity, felt particularly by the later settlers in that

region, whose crops may parch while those of their predecessors take all the water easily available for irrigation, in the season when it is needed; and also by those settlers who have been tempted to push farther and farther west in the moister years to suffer in a drier series of seasons which follows. There is little wonder that among such persons any plausible theory regarding the possible artificial production of rain, earnestly and sincerely advocated, should find a large following, and that they should wish to have the Government undertake to test such theories by experiment. While it is certainly not creditable to congressional action to undertake experiments upon the artificial production of rain in our present knowledge of meteorology, it is, perhaps, not surprising in view of the arguments that affect congressional action that several thousand dollars should have been appropriated for such a purpose.

In the West we find the people largely predisposed to believe any theory of the artificial production of rain, and to accept any statements regarding the general increase in the rainfall in their region in successive years. How far this is a sincere belief, or how far it comes from a desire to make the best of difficult conditions, it is hard to say; but certainly both these views have many warm advocates. Several years ago I met a very intelligent military man, the commandant of one of our Western posts, who firmly believed not only that the rainfall was regularly increasing in that region, but that the cause of the increase was the laying of rails and the stretching of wires along the railroads over the plains, which resulted, as he said, first in the equalization of electrical conditions of the atmosphere, and then in the more active formation of rain.

The chief advocate of governmental experiments in the artificial production of rain is Mr. Edward Powers, Civil Engineer of Delavan, Wisconsin, who has published two editions of his book, entitled "War and the Weather," the later edition being issued in 1890, and who has successfully memorialized Congress and with the championship of Senator Farwell secured the appropriation of a sum of money, which has now been expended in experiments with explosives in Texas. Mr. Curtis' paper will tell us of the result of these experiments. What I wish to consider here is whether, independently of the experiments, there is any reason for us to look hopefully upon the theory that rain can be artificially produced. Mr. Powers is evidently a perfectly sincere writer, entirely convinced of the truthfulness of his theory.

He very naturally dislikes the tone of certain criticisms that have been made upon his book; the tone may fairly be resented, but the criticisms can hardly be escaped by a writer who advances theories so strongly at variance with results of physical observations and discussions by men as sincere as he is, and at the same time much better informed upon subjects bearing on meteorology.

Mr. Powers gives in the first part of his book the facts that led him to believe that explosions may produce rain. The explosions to which he refers are in nearly all cases the cannonading in battles, the battles for the most part being those of our Civil War. It appears to me that this part of his book is inconclusive, because he does not take account, in the first place, of the comparative frequency of rains in our country, and in the second place, of the effect, not that battles would have on weather, but that weather would have on battles. When we remember that rains are not infrequent phenomena, and also that military operations are undoubtedly guided in great part by the condition of roads and sky, it does not seem at all impossible that the rains following the battles that he mentions are independent of them, and that all the coincidences of occurrences that he mentions are accidental. The interval between the battles and the rains they are supposed to cause vary from a few hours to one or two days, precisely as might be expected if the relation were accidental. The area over which the rain occurs is not stated; nor is the place known where the rain began. Mr. Powers, indeed, admits that he has not proved his case to the point of absolute demonstration, but he contends that the relation of cause and effect is made so likely that it is almost a duty for the government to undertake experiments by which the question will be settled; for if settled favorably, the results would be of so enormously great importance to the West that the little expenditure in the experiments would be returned many thousand fold.

After reaching the conclusion that rains do follow battles, he proceeds to examine the question from the side of scientific meteorology to determine whether his conclusion is in accordance with our knowledge of other facts with which it is connected. In this, he first states the general theory by which rain is produced. He then considers the source of the vapors from which the rain comes, and the processes by which these vapors are naturally condensed in rain storms; he finally asks whether

the effects of concussions, such as are produced by cannon firing and other explosions would not result in other disturbances which might artificially produce rain in a way very similar to that in which it is produced naturally. I will review these several points in order, but it might be stated at the outset that Mr. Powers is evidently ill-informed both as to facts of observation and as to theories of process.

The general theory of the production of rain to which Mr. Powers refers is stated on the eighth page of his book in an extract from Sillman's *Principles of Physics*. It is simply the old Huttonian theory of rain, in which condensation of vapor results from the intimate mixture of two masses of air, both saturated but at unequal temperatures. This theory was one to which meteorologists in the first half of this century gave the most attention, and it seems still to be regarded by many as the most important way in which vapor is condensed to rain; but while it undoubtedly involves a true process, it is as undoubtedly of little application in meteorology. In the first place it is very uncommon to find two large and contiguous masses of air, both saturated and at different temperatures. In the second place it is unusual for such large masses to mix intimately. In the third place it is impossible to produce from mixture of such masses, even if it occurred, the amount of rain actually observed, unless the winds by which the mixture was accomplished were of vastly greater velocity than we have any reason to suppose they are. The process depends, in a word, on unlikely conditions, and even if occurring, is ineffective. When rains do occur, there is every reason to think they are not produced in this way.

The winds to which Mr. Powers refers as the chief source of our rains are the lofty upper currents which flow at a height so great as not to be deprived of their vapors in crossing the mountain ranges of the western part of the country. These winds he supposes, following Lieutenant Maury in this, have had their source in the southern hemisphere as the southeast trades; there they gathered vapor from the South Pacific Ocean; they rose in the equatorial belt of calms, crossed over the equator, interlacing with the northeast trades which there flowed into the southern hemispheres, and then, advancing above the northeast trades and turning eastward they appear in a great high-level current sweeping over North America and the North Atlantic and even carrying some of their South Pacific vapor to

fall as rain in Europe. It is upon this understanding of the circulation of the winds that Mr. Powers so emphatically states that our rains do not come from the moisture of the lower air; that it is not the dampness of the lower air that makes the rain, but the rain that makes the dampness of the lower air (p. 116). It is out of the question to suppose that the northeast and the southeast trade winds of the Pacific systematically cross each other, the southeast trade wind alone supplying the lofty equatorial overflow in the northern hemisphere. It is equally out of the question to suppose that the vapors gathered by the southeast trade winds in the South Pacific should still remain in large quantity in the high-level current after its ascent. The greatest part of these vapors must have been condensed, to fall as the heavy equatorial rains of the doldrums; and the little vapor that remains in the cool lofty current is insufficient to saturate it. Notwithstanding this, Mr. Powers refers to the upper current as being probably warm and very fully saturated with vapor (p. 89). As far as observations go on mountains, they show that it is not warm, and that it is comparatively dry.

The air which is to be mixed with the equatorial current in order to produce condensation and rainfall is the hypothetical northeast polar return current, which is supposed to flow above the equatorial current at a still greater altitude. This is also taken from Maury's theory. Its existence is entirely out of the question. The current, as described by Maury, rests entirely upon hypothetical considerations. Its direction and its characteristics are not determined by observations, but by suppositions; and, in the light of modern facts and studies, the suppositions are emphatically wrong. In the first place, the polar return current of this hemisphere cannot be supposed to come from the northeast, but from the northwest. This would, at first sight seem to make little difference to Mr. Powers' theory; but it appears in *Science* for October 30, 1891, that the opposite course of the two currents whose mixture produces our rains is regarded as a reason for the stationary position of the mingling currents over the concussions of a battle-field until rain begins to fall from them, perhaps a day or two after the firing of cannons has ceased. Then a progressive movement begins to the east. In the absence of any lofty current from the northeast, a stationary storm-embryo could not be thus explained.

In the second place, the polar return current is certainly not above the equatorial overflow; the polar current is below the

equatorial. It is not my intention to enter into the well reasoned arguments by which this statement may be supported; these arguments need more attention from those who are unacquainted with them before it would be worth while to rehearse them here. But I do not think that any well-trained student of terrestrial physics can look into this question without being convinced that it is impossible for the return current from the pole to flow above the equatorial current. If those who are acquainted with Ferrel's discussion of this problem, and of the later contributions to it by Oberbeck, Siemens, Sprung and others, should maintain that the polar current lies uppermost, it would be interesting to read their reasons for dissent.

In the third place, the polar return current must be even less saturated with vapor than the equatorial current. It returns obliquely from the poles towards the equator; its temperature rises as it advances; its capacity for vapor thus increases and whatever small amount of vapor it had in the polar regions is no longer nearly sufficient to saturate it when it regains our temperate latitudes. Neither the equatorial nor the polar current is in the condition for the production of rain by mixture, even if such mixture occurred.

The large importance given by Mr. Powers to Maury's theories indicates a small knowledge of the work of more recent meteorological studies. Maury's fantastic theories of the source of our rain-making winds in the southern hemisphere, of the crossing of the trade winds over the equator, and of the northeast polar return current are entirely omitted from the modern understanding of meteorology. If the reader cares to refer to that most entertaining and plausible book, the "Physical Geography of the Sea," and carefully sift out the facts from the fancies there presented, he will find it to contain, in the first place, a valuable store of information about the ocean, gathered chiefly from the logs of American vessels; in the second, a most curious series of gratuitous suppositions regarding the circulation of the winds. Maury has practically no followers among modern meteorologists. The large credit that he obtained from his persevering collection of observations was well deserved and gave him an enduring name; but his friends would hardly refer to his unphysical theories as contributing to his permanent reputation, however much attention they may have at first attracted. In the view of his notorious failure to account for the motions of the winds, it is curious to read in a letter by Mr.

Powers, published in *Science* for October 30, 1891, the following statements: "Professor Maury gives very strong reasons for believing that there is a polar current there [above the equatorial current] flowing in nearly the opposite direction. Has any one ever given as good reasons for believing to the contrary? . . . . Has his theory of the circulation of the atmosphere ever been overturned, or even seriously attacked?" It is natural enough for one who is so little informed on the present state of meteorology to base his arguments on Maury's book; but it is unfortunate for the arguments.

Next in order is the process by which the mixture of these two hypothetical currents is to be effected. Mr. Powers says very little on this question that will stand in the light of modern meteorology. He mentions the results gained from the work of the Signal Service, but he appears to be entirely ignorant of the many other results gained by many other investigators, although he does not approve of such ignorance in others. For example, Professor Silliman believed that rains come from the vapor in the lower atmosphere, and thought that no amount of cannonading would bring water from the dry air of Arizona, thus ignoring the existence of any lofty air currents charged with vapor. To this Mr. Powers replies that it was twenty years ago that Mr. Silliman wrote the letter in which he expressed these opinions, and that he then held simply some of the old ideas of Hutton and Espy (p. 117). "Meteorology at that time," Mr. Powers goes on to say, "had probably been more neglected than any other science." Whether the latter charge is true does not matter; it is certainly true that meteorology has greatly advanced since the time of Hutton and Espy, and again since the time of Professor Silliman's writings. What appears to me the chief weakness of Mr. Power's theoretical discussion is his insufficient acquaintance with this advance. Had he understood the processes to which rain is now ascribed, and the strong reasons by which they are advocated, he could hardly have imagined that concussion would be reasonably associated with them. He maintains (p. 93 *et seq.*) that by means of concussion in the lower atmosphere, the exact equilibrium of the lofty currents from the equator and pole may be disturbed, and that the two may consequently be mixed together. This is out of the question, because in the lofty atmosphere there is excellent reason for believing that the air is in a state of decided stability, and not in the exact equilibrium

from which mixture might easily result. Very strong disturbances would be required to cause an overturning sufficient to mix large volumes of air from the two currents referred to; not that any significant fall of rain would result from their mixing, but that the mixing on which Mr. Powers bases his whole explanation is impossible without the expenditure of a great deal of energy.

The explanation that Mr. Powers gives to illustrating the manner in which concussion may precipitate vapor from the air is entirely contrary to the teachings of physics. He likens the action of concussion upon the atmosphere to the effect of a blow given upon one of a series of balls arranged in a line. The impact would be passed through the balls and cause the one at the further end to move; but if some of the balls in the series are of glass and contain water, they will be broken by the shock and the water would run out. "Suppose, similarly, that in a row of molecules reaching from the cannon's mouth into the heavens there are two molecules of aqueous vapor adjacent to each other; would not a heavy shock of concussion shatter the envelopes of heat by which they were surrounded and cause the two to unite into one particle? And if there are many molecules of vapor lying on such lines, would not the number of such condensations depend upon the force of the shock?" The discredit that the theory of artificial rainfall has gained is natural enough when we find it advocated by such a parody of scientific argument as this.

The modern theory of rainfall, gradually built up by the labors of many meteorologists and physicists, ascribes the production of rain to various processes, all of which depend on the direct cooling of a mass of air containing vapor, not by mixture with cooler air, but by some change in its own condition. The Huttonian theory of mixture is not excluded as impossible, but set aside as of small value, because the conditions for its occurrence do not appear in the workings of the atmosphere. Cooling of the air containing the moisture is regarded as the simplest and most probable process of rainmaking. This may be accomplished in various ways. Cooling by direct radiation from the air itself is probably of small value, although on the upper surface of winter cyclonic clouds it may be effective to an appreciable degree. The poleward motion of vapor-bearing winds carries them around the curvature of the earth so that

they are less favorably exposed to sunshine; their temperature therefore slowly falls, approaching and reaching the dew point, and then cloudiness begins and rain may soon follow. The region, however, over which the poleward winds of the general circulation are supposed to blow is not continually cloudy or showered with rain. Some other process therefore is looked for to aid the one just mentioned. Among other processes there is one which is effective at least in winter, and that is the movement of winds from the temperate oceans over the cold lands. Such winds cool not so much by contact with and conduction to the cold ground as by radiation to it, thus cooling until they become damp and cloudy. Even this process, however, does not seem to be so effective as the one yet to be mentioned, particularly in the Eastern United States, where the prevailing winter winds blow off the land. The cooling that must accompany ascensional motions of the air is thought to be the most effective cause of clouds and rain. Espy was the first to introduce this idea clearly into meteorology, and it has greatly gained in favor since his day. The ascent of the air may be accomplished in various ways. The motion need not be vertical, but must contain a vertical component. The trade winds, so long as they flow evenly over the ocean surface, are not rainy winds, although they contain a plentiful supply of vapor; but if they meet a mountainous island or flow against a bold coast of the mainland, they are constrained to ascend over the obstruction; they cool as they ascend, become cloudy and give out rain in great quantities. The heavy summer rains that fall from the southwest monsoon when it strikes the Ghats of India are examples of this process. Another method by which ascent is frequently produced depends on local convectional action. This may be caused by a surcharge of heat and vapor, as in the lower layers of the calm air of the Doldrums, where heavy diurnal rains occur; or it may depend simply on the super-heating of the lower air, whereby it becomes unstable with respect to the overlying strata, even to the point of overturning; this we see in a small way in the production of ordinary diurnal cumulus clouds; while in warm summer afternoons the same process in a larger way produces those overgrown clouds which develop into thunder-showers. It is noticeable that many of the rainstorms which followed the battles mentioned by Mr. Powers were thunder-storms, and it may be confidently asserted that these are

not the result of the mixture of equatorial and polar currents, but are produced simply by a convectional overturning of the lower air.

Finally, there are vorticular movements or cyclonic storms produced in the general circulation of the atmosphere whose course is at present not fully ascertained, but whose whirling and ascensional currents are well demonstrated by many observations. In the torrid zone, the cyclones appear to be truly convectional; in temperate latitudes, there are good reasons for thinking that the cyclones of winter at least are eddies of the general atmospheric circulation. The vertical component of the winds in cyclones requires that the ascending air shall expand, cool, become cloudy, and let fall rain or snow. Nearly all our rainfall comes from cyclones or thunder-storms. The rainfall of cyclones generally begins after a slow development of the centres of low pressure. The centers commonly develop in the West, and may be perceptible as faint areas of low pressure upon the weather maps a day or so before their clouds are expanded and their rainfall heavy. They drift along with the general motion of the currents in which they are formed, and hence advance generally east-northeastward. With the evidence now in hand, it is utterly out of the question to believe that these cyclonic storms are caused or in any way controlled by the comparatively small concussions that cannonading may produce in battles, or that the explosion of dynamite and gas balloons produced in Texas last summer. The enormous amount of work to be done in causing convectional or cyclonic movements in the atmosphere finds no adequate cause in the comparatively trifling undulatory disturbances that explosion may cause in the lower air.

Mr. Powers was, as I have been informed, with the rain-making expedition in Texas last summer. It would be interesting to learn whether he regards the experiments there successful in upholding his theory.

HARVARD COLLEGE, January, 1892.

THE GREAT EARTHQUAKE IN JAPAN.

BY Y. WADA,
Of the Tokio Central Meteorological Observatory.

The annexed map shows the region affected by the earthquake of October 28, 1891, whose epicentrum is in the center of the Island of Nippon (the largest island), in the departments

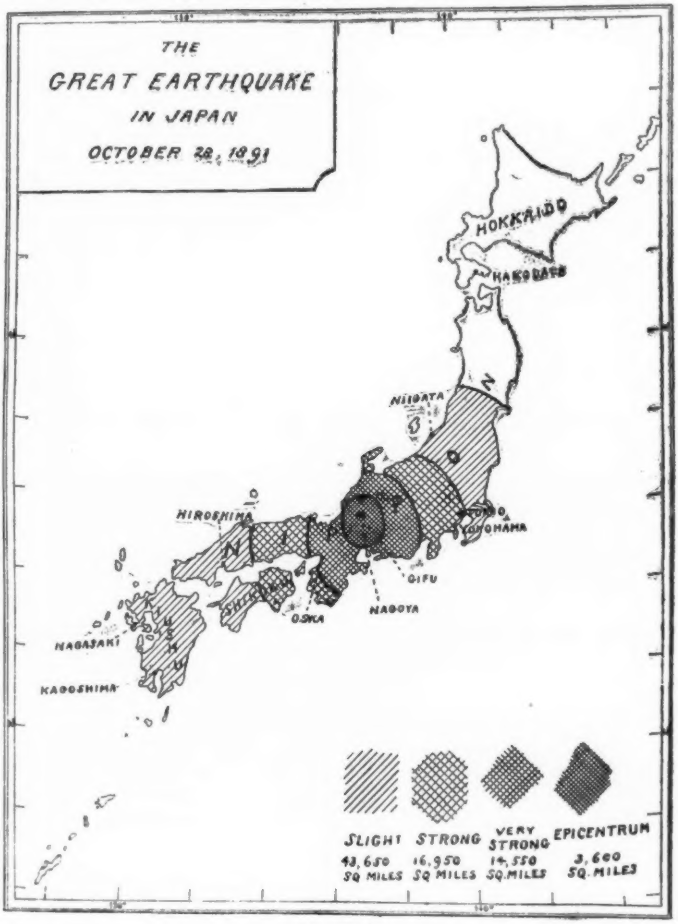


FIGURE I.

FIGURE 2.
Ruins of the Brick Post and Telegraph Office at Nagoya.

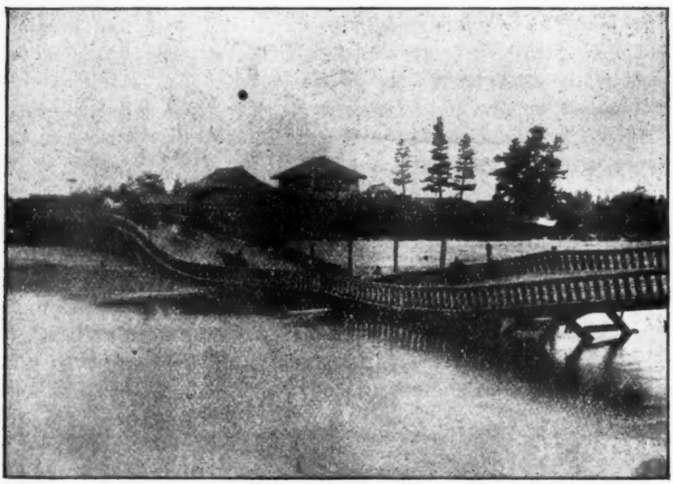


FIGURE 3.
Wooden Bridge thrown into the River at Biwajima.

of Gifu and Aichi, and includes an area of 3,600 square miles. The cities of Nagoya (160,000 inhabitants), and Gifu (population 30,000), alone count more than 10,000 victims, and 10,000 houses destroyed. The damage is also great for the other cities near the epicentrum. The railroads are twisted in zig-zags, the bridges are bent into waves (see Figure 3), the ground is furrowed with fissures of great length and considerable breadth, as shown in Figure 4, many hills have been leveled, while others have been elevated several hundred meters. According to the last advices, the epicentrum appears to be at

FIGURE 4.
Fissures produced by the Earthquake in the Village of Tamanoc, near Nagoya.

the end of the Neo Valley, canton of Ono, department of Gifu, where the ground is engulfed over an area of twelve square miles, from which it may be conjectured that the cause of the catastrophe is the collapsing of submarine grottoes.

Fortunately, the meteorological stations suffered no damage, and as the instruments were uninjured, the observations are being maintained. The shocks diminish from day to day, but have not yet ceased, the station at Gifu having registered, from October 28 to November 3, more than 500 seismic disturbances. The time of the first shock, on October 28, its direction and

movement at some of the stations, twenty-six of which observed the earthquake, were as follows:

STATION.	LONG.	LAT.	TIME.	DIRECTION.	MOVEMENT.
Gifu,	136° 46′,	35° 27′.	$6^h\ 37^m\ 11^s$.	N-S.	Vertical.
Nagoya,	136° 55′,	35° 10′	$6^h\ 38^m\ 50^s$	SSE-NNW.	Vertical.
Osaka,	135° 31′,	34° 42′	$6^h\ 38^m\ 15^s$	E-W.	Horizontal.
Nagano,	138° 10′,	36° 40′	$6^h\ 38^m\ 20^s$	SW-NE.	Horizontal.
Kioto,	135° 46′,	35° 1′	$6^h\ 38^m\ 41^s$	E-W.	Horizontal.
Tokio,	139° 45′,	35° 41′	$6^h\ 39^m\ 11^s$	E-W.	Horizontal.
Hiroshima,	132° 27′,	34° 23′	$6^h\ 40^m\ 45^s$	NW-SE.	Hori. & Vert.
Niigata,	139° 3′,	37° 55′	$6^h\ 41^m\ 00^s$	NW-SE.	Horizontal.
Matsuyama,	132° 45′,	33° 50′	$6^h\ 42^m\ 10^s$	ENE-WSW.	Horizontal.
Wakayama,	135° 9′,	34° 14′	$6^h\ 42^m\ 15^s$	NNW-SSE.	Horizontal.
Kagoshima,	130° 33′,	31° 35′	$6^h\ 47^m\ 53^s$	SE-NW.	Horizontal.

At the present time everyone is aiding to help the sufferers. The police are inadequate for the public safety, and the national guards and the engineers are at the scene of the disaster seeking the unfortunate persons who are buried in the ruins, or burned by the fires engendered by the earthquake, while the army surgeons and those of the Red Cross are in the field. During three days neither the railroads nor the telegraph lines were working, owing to the destruction caused by the earthquake.

TOKIO. November 7, 1891.

ELECTRICITY AND STORMS.

BY PROF. H. A. HAZEN.

For more than ten years I have been trying to obtain a definite connection between atmospheric electricity and storms or high areas. It has seemed highly probable that the explanation of these seemingly opposite conditions would be a common one, or as it might be put, one was dependent upon a negative form of manifestation while the other was positive. The question naturally arises, can there be a relation between phenomena unless it is that of cause and effect, or that of a common source of energy which produces some effects that are alike in both phenomena? It would appear, at least, that, unless one or the other of these hypotheses be true, it would be of little purpose to prove any mere coincidence between different forces or manifestations of energy.

Dr. Welling, president of Columbian University, once presented to the Washington Philosophical Society a principle

which seems of extreme importance in this discussion. The substance of this principle is the following: Any number of coincidences between phenomena are of no value in showing a relationship unless we can show *a priori* how such a connection can exist. An illustration may be given, I think, from the early Ptolemaic system. The ancients had seen for ages that the sun appeared to rise in the east and traverse the heavens day after day. The coincidence was absolute and the final deduction was easily made that the earth stood still while the sun moved at varying heights above the horizon at different times of the year. There would appear to be at least one exception to this principle, and that is when we note an instantaneous coincidence between phenomena. For example, Prof. Young, at Denver, while watching the sun saw upon it a very violent outburst, a prominence suddenly stretching or shooting thousands of miles from the sun's surface, he at once noted the exact time and at dinner remarked upon the singular appearance. The observer of the magnetic needle stated that just at that moment his needle gave a most violent swing. Now, while we have to assume that the form of energy that produced the swing must have had the velocity of light as well as other elements in common, yet the probability that there was a mere coincidence in this case is so extremely small that we may safely consider either that one and the same source of energy produced both phenomena or that one was the result of the other.

A very different state of affairs supervenes when we try to connect, for example, the appearance of spots on the sun with fluctuations of atmospheric temperature. One such attempt was made in the case of Hohenpeissenburg (a mountain in Bavaria 3,000 feet high) some twenty years ago. The hypothesis was that if we take observations of temperature at an isolated peak they would be much less affected by local causes, and hence would give a much more satisfactory basis for comparison. In fact, there is little difference between the larger fluctuations at Hohenpeissenburg and at Munich, at its base. The original observations used extended only to 1850 and, by using the annual mean temperature, a rather remarkable coincidence was discovered and announced, namely, that years of maximum number of sun-spots were years having a diminished temperature. The subsequent years, however, showed that this rule did not follow, but, in fact, was just reversed, so that in 1884 the maximum spottedness coincided with a maximum of

temperature, and, I think, it is generally recognized to-day that the bulk of temperature records rather lean toward a maximum during a period of increased number of spots. This would seem a very good illustration of the delusive character of mere coincidences in establishing any relationship between diverse phenomena.

It would seem necessary to establish some relation between the phenomena of electricity and storms other than that of mere coincidences. It has been known for many years that the electrometer gives negative electricity when rain is falling, and positive with a clear sky and generally with snow. The latter is remarkable and somewhat difficult to understand, but, I think, it may be admitted that increased humidity resulting in rain is attended by a negative potential, while an absence of moisture indicates a positive potential. That electricity is a common accompaniment of summer storms is absolutely established, and though it is generally regarded that this manifestation of energy is brought about by the storm and has nothing to do in producing it, yet the evidence bears quite strongly in the other direction. It is generally believed that the vapor molecules are kept apart by electric repulsion, and it is a common observation that after a flash of lightning there is often a violent and sudden downpour showing that the molecules have united suddenly through some form of electric action. While it cannot be said positively, that electricity is the most important cause in producing a thunder-storm, yet it may be regarded as capable of energizing it. It is but a step from the summer thunderstorm to the winter storm and we can easily explain why it is that lightning does not manifest itself in the cold of winter.

A definite connection may be established between electricity and all storms in the following indirect way: It is well known that there are many persons peculiarly susceptible to the influence of atmospheric electricity. Such persons, while sitting in their chairs and totally unconscious of the approach of a thunderstorm, become affected in an unmistakable manner by this electric influence, and are perfectly able to predict an impending storm without seeing the sky. This peculiar feeling remains until a flash of lightning relieves the tension and the sensation becomes normal again. An influence of this kind is felt at all seasons of the year by those who have lost a limb, and I have known such men who were able to predict the approach of a storm a day in advance, though the sky might be

perfectly clear at the time. Capt. Catlin, who lost a limb in the rebellion, has made careful and intelligent observations of these sensations for more than twenty years, and has no hesitation in saying that they are not due to changes in temperature, pressure, humidity, wind or any other recognized atmospheric element, but that they are caused by atmospheric electricity. To my mind it is a little remarkable that definite and persistent efforts have not been made by the medical fraternity to establish absolutely just the cause of such sensations. It would appear that the method of treating patients might be vastly improved, if it could be learned that under perfectly definite atmospheric conditions plainly indicated on our weather maps one kind of electricity was present, and on another day an entirely different kind, while in the first case all patients were greatly depressed and under the latter much invigorated. It would not seem a very difficult undertaking to put such patients under different electric influences, and thus ascertain if the atmospheric or storm and high area influence could be simulated or duplicated. This seems a promising line of investigation, both for the physician and meteorologist.

A scientist in England has very recently made some experiments on electric evaporation, and has found that, when he positively electrified a vessel of water, no evaporation ensued, but, when the same vessel of water under the same conditions was negatively electrified, there was a marked evaporation. The proof would have been more satisfactory if he could have placed the positively electrified water in a saturated air, and by that means added to its weight. It is not certain but that there may have been a slight heating in the negatively electrified water, though he tried to avoid it. This seems a most remarkable experiment, and if it can be substantiated it may prove a most valuable line of research in meteorology. It is well known that the humidity of the air is one of the most constant of all phenomena. No change in heat, in pressure, wind or any other commonly recognized element produces any effect whatever upon the amount of moisture in the air. On the approach of a storm, however, the moisture is remarkably increased, and, in fact, the heat in front of a storm may be due to the increased action of the sun upon moisture in the air. Oval areas of great extent have the moisture more than doubled, and this often occurs in a perfectly still air. On the other hand, after a storm has passed, the moisture disappears as remarkably as it

appeared, and this, too, in a calm air often. May we not put these ideas together? May there not be a change in the evaporative influence at the earth's surface entirely different from the heat or wind or any thing else commonly recognized? If this be so, we have a most interesting line of study in this direction.

The rather uniform and rapid motion of storms from west to east in this country has never been satisfactorily explained. It certainly is not due to the motion of the upper current for that has a different velocity at different layers as we rise in the atmosphere. May there not be a very definite connection between electric currents, which we know have a remarkable tendency from S. W. to N. E. from the appearance of clouds, and the tendency of storms in the same direction? Finally, may we not consider that our storms and high areas form a dual condition in the atmosphere? In other words, that they are essentially electric fields in the atmosphere, the one negative, the other positive. These fields may depend for their source of electrification or energy upon the electric influences from the sun, or they may be fed and sustained by electric action having its seat in the earth's crust. It would seem as though the continual presence of differing manifestations of electric energy in our storms and high areas is abundantly proved. To my mind, these do not appear to be consequences of storms and high areas, but electricity itself, in some way, perhaps little understood, is the vital principle energizing all these conditions.

December 25, 1891.

MEDICAL CLIMATOLOGY, HOW MAY IT BE ADVANCED?

By Dr. W. J. Herdman.

There is great need of more minute and exact information regarding the influence of the climates of the United States upon the arrest and cure of disease. As the country grows more populous, and wealth accumulates, and the facilities for travel improve, the custom of changing residence for certain seasons of the year is becoming a common one with many of our people, while others are forced, by failing health or the ravages of some special disease, to seek a climate more congenial to an enfeebled body.

The climatic resources of our country are unsurpassed by those of any other country on the globe, by reason of its long reach of seaboard, east, west and south; its extensive plains; its many mountain chains; its forests, lakes and rivers, infinite in variety and well distributed, and the breadth of latitude it covers. But so far, while there have been many who would and do avail themselves of the benefits offered by change of climate, our physicians, those to whom we look for safe advice as to where or when to go in order to secure the maximum advantage from a change of residence, are but meagerly furnished with the necessary information regarding localities suitable for the invalid. Perhaps a deficiency even more elementary is not altogether lacking in those of whom such advice is asked. It is even possible that some physicians may not know the effects of certain elements of climate upon the normal man, and are even less prepared to weigh carefully their influence upon the sick; but this is a fault in their medical training or perhaps may be owing to the fact that the range of action of such influences upon the human organism is not yet fully determined. Certain it is that one of the first needs for making a proper use of climate as a therapeutic agent is to fit those who are to prescribe it for doing so intelligently, and this means to include in the curriculum of every medical school worthy of the name instruction in medical climatology. But assuming that the medical adviser is equipped with the necessary information as to how man is affected by moisture and dryness, differences in temperature or atmospheric pressure, salt sea air or the balsamic emanations from pine forests, prolonged sunshine or the reverse, prevailing winds or atmospheric stagnation, and how they may be utilized for his relief when diseased; where can he turn for accurate and unbiased information as to how these agencies are combined in any one locality at any particular season? Surely the partial and one-sided and oftentimes exaggerated statements of ambitious proprietors of sanitariums and summer-resort hotels are unsafe guides, while the statistics scattered broadcast by railway officials and land speculators are even less trustworthy. Such information must, in order to insure confidence and bear the test of experiment, be free from all suspicion of bias. Statistics must be gathered of the needed kind by skilled observers with no ulterior object than to obtain the facts and record them faithfully.

Let us inquire, then, what facts are needed by a medical adviser concerning any region of country before he may safely advise his patient to make it a place of residence for the relief of some bodily or mental ailment? When we consider the variety of influences which affect mankind, we find entering into this problem other factors than those that are included under the head of climate or meteorological conditions. The soil, the scenery, the inhabitants of a district and their manner of living, have often as much to do with the recovery of an invalid visitor as the climate. We must not, therefore, leave these things out of account, for although they may not, strictly speaking, come within the limits which the title of this article covers, yet from a practical point of view, Medical Climatology, from the standpoint of the practicing physician, must needs cover this ground also to be of practical value to him in his work.

The information to be gathered may be conveniently considered under the four following heads:

Meteorological and Climatic Conditions.

Terrestrial and Sanitary Conditions.

Social Conditions.

Health Statistics.

The most favorable views might be entertained of a locality should the range of facts under one of these headings be alone obtainable, while information regarding all might show it to be entirely unsuited to the needs of the particular patient or class of patients under consideration. Aside from the unreliability of much of our present knowledge concerning the so-called health resorts, it is entirely too limited in its nature, therefore too few of the elements are considered which go to make up that totality of effects by which a diseased body is brought to health.

Perhaps I may be able to make some not altogether impracticable suggestions by which certain of these differences can be corrected. And first as to the requisite

Meteorological and climatological data.—For a long period of years in connection with the signal service of the army, observations have been taken of many localities in our country by competent officers. Some of the stations where such records have been kept, chance to be located in regions claimed to exercise a peculiarly beneficial influence in the arrest or cure of certain diseases, but upon appealing to these records, with the

view of determining through what special climatic features such immunity is secured, it is discovered that the data are not such as are adapted to the physician's needs. Much that he must know in order to reach his conclusions has not been recorded. Monthly means and averages are of little service in estimating the effects of a climate upon an invalid as compared with diurnal fluctuations. Atmospheric purity or composition is often of much greater importance than the force or direction of the air currents. Statistics that have been gathered without any direct reference to the influence of their subject matter upon the human economy are poorly adapted for the solution of such problems. The observers are there and properly qualified. Their attention needs only to be directed to and their observations made to cover medical needs. It is generally conceded that the change of the Weather Bureau from the Signal Service to the Agricultural Department has greatly increased its usefulness to the country, since it is now placed in a position where it can be directly helpful in promoting our extensive agricultural interests without in the least detracting from its scientific value, or neglecting the needs of the marine service, or any other industry it has heretofore served. Might not the Weather Bureau still further enlarge its usefulness to the people, both as a scientific and practical agency, by including in its range of observations such phenomena as are known or suspected to have a bearing upon the physical well-being of man? The addition of this function to those already performed by the Weather Bureau might require the redistribution of some already existing stations; perhaps the addition of a few new ones in locations from which reports are not now received, but in comparison with the benefits that would accrue from adopting a method so economical and efficient, the little additional outlay that would be required in men and money would be trifling. This would furnish reliable information regarding the pressure and purity of the atmosphere, its dryness or humidity, the amount and seasons of rainfall, the variability of temperature, the relative proportions of cloudiness and sunshine, the direction and velocity of the winds and their effects upon the temperature and precipitation of moisture, presence or absence of ozone, and any other conditions which, as modifiers of the air we breathe and live in, are thought to influence human life or health. Only upon such a foundation can Medical Climatology be firmly established.

But while man is greatly dependent for health upon the influences that emanate from the "heavens above," the "earth beneath" is the source of no less potent factors, and the physician or invalid who considers the one and fails to inquire as to the other will make serious blunders. Among

The Terrestrial or Sanitary Conditons, I would include facts concerning the topography of the country; whether it be level or rolling, hilly, rugged or mountainous, marshy or arid; whether near the sea board or other large bodies of water; whether dotted by lakes or traversed by streams. Then the character of the rock and nature of the soil, the scenery and vegetation, the natural and cultivated products, the presence of mineral springs and their nature, the purity of potable waters, all should come in for their appropriate share of attention, because of their influence upon the mental as well as the physical nature of man, and the potency which they possess in modifying disease. Much information regarding such terrestrial conditions is already obtainable in the Agricultural Department, the Geological Survey office, in records of the Coast Survey, and those of the War and Navy Departments at Washington. But here again the observations recorded, not having been made with the object we now have in view, are necessarily incomplete or fragmentary. Whether it is practicable through these sources to secure all the information needed, is doubtful, but even if this should prove to be the case, assistants under competent direction would be required to present such facts in a form that would exhibit their relative importance as factors in determining the effects of climate.

But even the atmospheric and terrestrial conditions are not all. Many other considerations must enter into the question of the suitability of a climate for an invalid. Circumstances and conditions that influence the mind, and through the mind the body, must not be left out of the account. It is true that the influences already considered operate as much upon the mind if not more than upon the body, and in this way their good effect is brought about, but I have known the most favorable combination of climatic and sanitary conditions to fail of effecting the hoped-for cure for the lack of what may be appropriately termed

Social Conditions.—The race, character, customs and habits of the people among whom one may be forced to dwell in seeking suitable climatic conditions, may either nullify or

enhance their benefits. The nature of the food furnished; the cleanliness and comfort of their houses and surroundings; the expense of living; the opportunities for entertainment and amusement; the facilities for travel and out-door exercise; the congeniality of companionship, and all circumstances dependent upon the spirit and enterprise of the inhabitants are factors in the selection of a climate which in some instances perform an important rôle. The individual peculiarities of the patient, his mental as well as his physical requirements should be well understood by his adviser. Many failures in prescriptions of change of residence for the sake of improvements in health owe their lack of success to this oversight. Forced idleness for an active nature is of itself a serious impediment to restoration to health, and a locality in other respects favorable that will furnish suitable occupation to such an one will prove directly beneficial in ministering to both body and mind. We can safely trust to the enterprise of our excellent monthly periodicals and realistic novelists for meeting our needs in this direction, and for furnishing the required information in the most attractive form. Human traits and customs never fail to elicit interest, and he who can faithfully portray them is sure of an appreciative audience.

Health Statistics.—In order that a locality may establish a legitimate claim to the possession of natural conditions suitable to the cure of certain forms of disease, it must show immunity from such disease among those long resident there; as well as arrest and amelioration of symptoms on the part of those who seek its healing influences. But it not unfrequently happens that while a region, through its climatic or other conditions, may retard the development of some diseases, it renders the inhabitants prone to other diseases equally if not more to be dreaded, and of such possibility neither the advising physician nor the patient wishes to be kept in ignorance.

The instances that I can call to mind in a decade of practice, are too numerous to mention where patients, induced by the flattering reports of the benefits of certain climates in curing ailments from which they were suffering, tried them only to fall victims, in their weakened state, to other diseases incident to the locality, and of which they had no timely warning. Vital statistics, or more properly mortality statistics, for man deals with health as he often does with wealth, waits until death before he learns the lesson, it has become the custom of many communi-

ties to record. And in some places the record appears in bulletins and the terminal pages of medical journals in association with the statement of the current meteorological phenomena.

The etiological relation existing between a death from chronic dysentery and a syncronous tornado is not apparent to the ordinary mind, and yet there must be some very intimate interdependence between these phenomena, or they would not be so constantly associated together in the minds of all. The weather bears the curse of most of our ill health, rightly or wrongly, and is it not high time that we set ourselves about determining just how far its responsibility extends? Death records are of little value in the solution of this problem, but full vital statistics, including a faithful record of prevailing disease of all forms, taken in connection with the preceding as well as the present meteorological conditions, may reveal some connection between the two orders of phenomena that will serve as admonitions, and lead to prevention. Boards of health, with greater powers and wider range of action, more uniform in method and purpose, should be established in every State, county, city and village. It should be the duty of every physician to report to them forms of diseases he is meeting with from day to day. The nature of such diseases being known, their causes may be readily traced out and credited to their proper source in climate, soil or social conditions. If it was only for the benefit of the occasional wealthy individual who can readily avail himself of the wise or unwise advice of his physician and seek the promised benefits of change of air in distant climes, there would, perhaps, be but little inducement to attempt to remove the present uncertainty which surrounds the question of climatic influences on human health. But these influences are certainly exerted. Such forced migrations only serve to bring them to our notice. What are these influences? What are their injurious effects upon us, and how may we protect ourselves against them? The reply demands knowledge too wide reaching to be secured by ordinary limited agencies. The health of the citizens of a nation is its wealth. It is poor economy to waste it by failing to take the needed steps to preserve it. Noble efforts are being made by many States, cities and villages of our land to point out to their own inhabitants and the people at large the influences that tend to disease. They are doing good work, but its influence for good is limited. Is it not time that interests so vital to the welfare of the nation

should receive national recognition, and that some adequate provision should be made at the national seat of government for utilizing the material already obtained through other sources that might be made useful in this direction; for guiding and extending observations; for encouraging and unifying the efforts now being made by States and municipalities for the improvement and maintenance of health?

A National Bureau of Health, located in Washington, would prove of eminent service to the nation, and it is gratifying to see how general is the interest which this subject is awakening.

AN ACCOUNT OF THE "LESTE," OR HOT WIND OF MADEIRA.

By H. Coupland Taylor, M. D., F. R. Met. Soc.*

I had intended bringing before this Society, with their permission, a sketch of the climate of Madeira, but finding it would necessarily extend to too great a length, I am confining my present remarks to one of the most interesting phases of that climate, namely, to an account of the "Leste," or hot wind which is occasionally experienced in that island.

Being an invalid, I must beg for the indulgence of the Society for irregular times of observation and other defects the Fellows may discover in the following paper.

I must first state that my instruments are placed in a regulation Stevenson screen, and the blackened bulb *in vacuo* thermometer upon a post about four feet from the ground. The maximum and minimum thermometers are by Casella, and duly tested at Kew, while the hygrometer (Mason's dry and wet bulbs) is by Negretti and Zambra. I also have had in use for some months a self-registering hair hygrometer by MM. Richard Frères of Paris, as likewise a thermograph by the same makers; but no very severe Leste has occurred since I had them.

This "Leste" is a very dry and parching wind and sometimes very hot, blowing over the island from the east-north-east or east-south-east, and corresponds to the Sirocco of Algeria or the hot north winds from the deserts of the interior experienced in Southern Australia, and locally known as "Brickfielders." It has been likened also to what is known in Italy and Sicily as the

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*Quar. Jour. Royal Met. Soc., Oct., 1891.

Sirocco, but notwithstanding that both winds have the same origin they differ materially; for this latter having become saturated with moisture in its passage over the Mediterranean, is, as a rule, damp and enervating, a great contrast to the Leste of Madeira, which, as I have before mentioned, is very dry. Occurring in such an equable climate, both as regards temperature and humidity, as that of Madeira, it possesses some special features of interest and no doubt attracts there a more general attention than it would do in some other more variable and extreme climates.

Its general characteristics were thus described by Dr. Heineken, who took careful observations in Madeira over sixty years ago, from the years 1826–1831, and the description fairly depicts its general character. He says: "It reaches us immediately from the coast of Africa, after passing over 300 miles of sea; not a cloud is to be seen during its continuance, the whole atmosphere is of one uniform unvaried blue" (a rare occurrence in Madeira) "of a peculiar character, as though viewed through what a painter would term a thin warm ærial haze. It blows from the east and south-east, lasts almost invariably three days, and encounters you like the puffs from the mouth of an oven or furnace. . . . Birds and insects seem to suffer from it more or less. . . . . Furniture warps and cracks, books gape as they do when exposed to fire, and it is generally inconvenient and oppressive."

Mr. Yate Johnson, in his *Handbook to Madeira*, in the excellent chapter on its climate, adds: "It usually begins as a gentle warm breath, afterwards there is more motion and sometimes the wind increases to a strong breeze. . . A thin haze extends over the land and gradually thickens out at sea until the horizon is completely hidden, and in that direction a low bank of grey cloud is seen in the east and south. In the earlier stages the Desertas are dimly perceived backed by a white cloud, but afterwards they become invisible." (The Desertas are a small group of islands only ten or twelve miles distant.)

The special characteristics of this wind may now be described in more detail:

It doubtless originates on the heated deserts of the Sahara, and is strictly analogous to the Sirocco of Algeria. As the air becomes heated it rises there in whirlwinds, carrying with it quantities of sand and dust to be borne along for hundreds of miles out to sea above the cooler north-east trade current. It

then gradually descends far out in the Atlantic, where it is experienced as a hot, dry, and often boisterous wind in Madeira and the Canary Islands, where it is called the "Levante." The reason why it does not become moist and enervating like the Sirocco of Palermo and parts of Italy by passing over the intervening sea is, I presume, due to its travelling at a much higher altitude in the former case, and thus it does not come into contact with the sea till it reaches the longitude of Madeira or thereabouts. But this wind is, no doubt, frequently modified before reaching Madeira, and so it may be asked what constitutes a Leste? and it is not always so easy to determine, as the indications of the slighter ones are not very pronounced, though those of a severe Leste are distinct enough. My opinion would be that there should be at least a difference of from 9° to 10° F. between the dry and wet bulbs, and this not merely at midday but at the morning and evening readings, and that this should be accompanied by a distinct rise in the temperature. Such a degree of dryness as these readings would indicate is never experienced in Madeira except when an easterly wind is blowing.

Its occurrence is quite uncertain. Many months may elapse without its occurring, whilst, on the other hand, two or three of greater or lesser intensity may be felt within the course of a few weeks during the summer months. It is most frequent during the months of July, August, and September; it occasionally also visits the Island in various other months, but being modified by the cooler temperature prevailing, instead of being intensified by the heat of summer, it passes by almost unnoticed by the public. If, however, the weather at such times is carefully watched, the sudden accession of a greater degree of dryness and warmth is clearly due to this cause. For example, on February 19th and 20th, 1889, the maximum suddenly rose from 64° on February 18th to 76° on the 19th, and the minimum from 53° to 66°.5, the significance of which is unmistakable when it is remembered that the extreme minima for a week together frequently do not vary more than 2°. Again, on looking at the relative humidity we find the indications equally plain, for on the 18th the relative humidity was 74 per cent. in the morning and 77 per cent. in the evening, whereas on the following day it had fallen to 42 per cent. and 37 per cent. respectively!

The duration of the Leste is generally stated to be three days, but it may last only one day, and, on the other hand, it may last up to six or seven; or, after lasting perhaps a day or two, it may

seemingly disappear entirely for one day, only to recur on the day following, *e. g.*, July 19th to 21st, 1890.

It is generally believed that the Leste is felt more severely at high elevations in the island than in localities nearer the level of the sea, but this has been questioned; on the whole, however, the evidence seems to establish the popular belief, although simultaneous observations have not been taken to a sufficient extent to absolutely prove it. But there seems no doubt of the fact that the climate on the hills is affected first, *i. e.*, before that on the lower levels. For instance, on June 6th, 1890, a Leste was reported from Camacha (2,300 feet) which was not felt in Funchal till the following day. Again, in a Leste noted by Dr. Langerhaus in September, 1883, the minimum on the first day at an elevation of 1,200 feet was 63°.5, whereas it was only 61° in Funchal. On July 10th, 1890, a Leste which was scarcely noticed at all in Funchal occurred at Camacha, when I registered a difference of more than 20° between the dry and wet bulbs, indicating a relative humidity of only 28 per cent.

The force of this wind is often considerable, causing a rough sea with crested waves, and attaining a force of from 4 to 5, or even 6, on Beaufort's scale. During its onset it gradually supersedes, while during its subsidence it is again gradually superseded by the Northeast Trade Wind, which is generally blowing steadily over the Island of Madeira during the season of the year when the Leste most frequently occurs.

As far as my observations go, the barometer shows no certain or decided movement. As a rule it rises slightly at the commencement, though that is not invariably the case. The fall after the termination of the Leste is much more regular and decided than any rise that may have taken place at its onset.

The sky is perfectly cloudless except for a low and ill-defined bank of cloud to the east and southeast horizon.[1] There is, however, a decided haze both over land and sea as seen near sea level, which gradually obliterates the horizon and renders the Desertas invisible, though they are only about ten miles distant and rise to the considerable elevation of 1,600 feet. This very marked haze, with such a dry wind and cloudless sky, is one of the most interesting features connected with the Leste, and many explanations of it have been offered. The usual one

[1] A peculiar oval-shaped cloud to which Professor Piazzi Smith has called particular attention is sometimes seen from Funchal at these times, and is said to indicate a Leste blowing at a high elevation.

adopted has been that it is due to the particles of dust from the Sahara floating in the upper regions of the atmosphere; indeed, dust has been deposited during violent Lestes in sufficient quantities to be collected by hand, but this very rarely happens. That there is at these times an abnormal quantity of dust in the atmosphere, even though it is quite impalpable, might be also inferred from the strictly analogous winds experienced near the Cape Verde Islands, where the amount of dust in the atmosphere causes what is known as the Red Fogs of those regions. Nevertheless, it is sometimes stated that the air during a Leste is "particularly free from dust." This statement may be so far true that there does not, as a rule, seem sufficient dust *per se* in the air to produce the haze which I myself noticed. For when staying at an elevation of 2,300 feet during the summer of 1890, when three Lestes occurred, the atmosphere appeared peculiarly clear and luminous on every occasion; very different from the haze usually seen from Funchal. From the above considerations, however, the evidence seems to prove that there is an unusual amount of dust floating in the atmosphere. During a Leste in September, 1890, I made an ascent to an elevation of 4,500 feet, and an observation I happened to make on that occasion may perhaps help to explain the nature of this haze. The haze on that day over sea and land was very marked, but the Desertas were just dimly visible. At an elevation of 2,300 feet (Camacha) all the higher points around were, however, perfectly clear, and the atmosphere quite luminous and free from all haze. It was only on looking down to lower levels that the haze was apparent. Now, on making a further ascent to an elevation of about 3,500 feet, curiously, all the highest points of the mountains in the Desertas began to stand out perfectly clear and distinct, while the whole lower thousand feet or so were barely visible, causing a remarkable effect. The difficulty in accounting for the haze lies in the fact that we cannot suppose it is of the nature of an ordinary sea mist; for neither could the temperature of the sea bring the air in contact with it to anywhere near the dew point, nor is there known to be any counter-current of cool air during the height of the Leste either on land or sea to lower the temperature of the whole body of air to the point of precipitation. But now bearing in mind the extremely rapid evaporation which is going on from the sea under the existing conditions of temperature and humidity; secondly, the increased quantity of dust floating

in the air at the time; and, thirdly, the fact recently demonstrated by Mr. Aitken that a solid nucleus is always necessary for the condensation of watery vapor in the forms of fogs, mists and clouds, may not the largely increased number of dust particles in the air have the power of attracting around themselves, and thus condensing some portion of the watery vapor arising from the sea in such large quantities, and thus producing the haze, which the simple presence of impalpable dust in the air is not capable of doing? Thus, while the haze is visible at the sea level and up to a certain altitude, at higher elevations, where the dry air still persists, the air remains clear and luminous.

We will now pass on to consider the conditions of temperature and humidity accompanying a Leste. The temperature rises considerably, but never reaches the intense heat experienced during the hot winds of Southern Australia or South Africa. The highest temperature reached is rarely much above 90°, but this temperature being accompanied by a wind of considerable force and of great dryness, is decidedly felt both by the inhabitants and also by the vegetation of an island climate with such an equable temperature. The highest temperature I can find recorded is 93°. During a Leste lasting from July 26th to 29th, 1882, recorded by Dr. Langerhaus, the thermometer rose to 90°.4, and the highest minimum was 74°.5. The minima are not as a rule so much higher than the average minimum as might have been expected with a continuance of the wind; a result due probably to the much less force with which it usually blows during the night, and to the rapid radiation taking place from the dryness of the air.

The relative humidity shows a marked variation from the mean, falling sometimes as low as from 20 to 25 per cent. In the above named Leste recorded by Dr. Langerhaus in 1882, the relative humidity was as low as nineteen per cent. It is remarkable how suddenly the change may take place. For instance, on July 9th, 1890, at 5 P. M., the dew was falling fast, the dry and wet bulbs standing respectively 61° and 59°, indicating a relative humidity of 88 per cent., yet at 7:30 P. M. the dew had entirely disappeared and the relative humidity had fallen to 43 per cent., there being 12° difference between the readings of the dry and wet bulbs.

The maximum reading in the sun by the blackened bulb *in vacuo* indicates during a Leste only a slightly higher tempera-

ture than on ordinary fine and clear days, though the heat of the sun feels very scorching, but the maximum solar intensity is usually less than on such a day; thus during a Leste in June, 1890, at Funchal, the shade maximum was 87°, the maximum in the sun 139°, and the maximum solar intensity therefore 52°; while on a fine day, *e. g.*, June 21st, with the considerable humidity of 71 per cent., the shade maximum was 73°.5, the sun maximum 134°, and the solar intensity 60°.5. At an elevation of 2,300 feet the same result obtained. On September 1st, with the difference of 18° between the dry and wet bulbs, or a relative humidity of only 34 per cent., the solar intensity was only 52°, while on a clear day, with a relative humidity at noon of 72 per cent., the solar intensity was 65°. Very similar results, though generally with slightly lower solar intensities, were obtained when the readings of the sun and shade temperatures were taken synchronously at noon, which is, perhaps, a more accurate method than taking the maximum of each for the day.

From these observations it would appear that the amount of moisture does not lessen the heat of the sun as much as would have been expected, or else on the occasion of the Leste the large amount of other suspended matter in the air interferes equally with it. The amount of ozone in the air is much diminished during a Leste. In a Leste of July, 1890, during the three days of its most marked prevalence, the mean was 2.1 in a scale of 0–10, whereas on the six previous days it averaged 4.5, or more than twice as much. When the Leste has blown itself out it is almost invariably followed by rain or a thick mist, for as it is gradually replaced by the cooler north-east wind, which is the prevailing wind all the year round in Madeira (*vide* Dr. Buchan's *Report on Atmospheric Circulation—Challenger Expedition*), the temperature falls, and the large amount of moisture absorbed into the air becomes condensed.

CORRESPONDENCE.

PERMANENT CYCLONE BELTS.

To the Editors.—In your issue of November, 1891, under the heading "Book Notices," occurs a brief criticism signed "Hz" of a short paper by the undersigned. This paper was read before the Technical Society of the Pacific Coast, and was published

in the Transactions of that Society in June, 1891, and is entitled "Physical and Geological Traces of Permanent Cyclone Belts."

The author of the paper desires to correct the misleading and erroneous statements of the criticism. He does not desire the fact that there is a permanent belt of cyclonic activity about the globe in lat. 50° to 60° N. to rest upon his statements and deductions alone. The existence of this belt was established by deductions legitimately and logically drawn from observations made years ago, and confirmed as thorough investigations are extended. Every monthly Weather Review now charts these lows substantially as indicated in the paper criticised.

The author substantiates the deductions from meteorological data, by three co-ordinated and confirmatory facts, individually well known to physicists: (1) that this belt is along the lines of maximum upheaval and denudation; and (2) that it is consequently the locus of the most extensive exposures of the oldest geological formations; (3) that maximum glaciation of, and dispersion from, this belt occurred during the Ice Age.

The first of these facts is the result of the inaugurating cause, namely, continued recurrence of decreased atmospheric pressure, resulting in excessive precipitation.

Had cyclonic energy and precipitation been distributed over other areas than the belt indicated, maximum denudation and exposure of the oldest rocks would not have occurred as at present along this belt; nor would the exposures of the later strata in the order of their ages have been disposed as now.

Glacial dispersion from this belt, irrespective in many instances of the slope, proves the concentration of precipitation upon it during the Ice Age. The resulting glacial denudation thus reinforced the subærial denudation occurring before and since the Ice Age.

Thus the concentration of cyclonic energy is distinctly traced upon the continent along the belt indicated; therefore the views expressed by the author do not rest upon a mere theory, but upon a correct interpretation of existing facts and conditions, and proper deductions therefrom.

The consequences of this concentration of denuding agencies are: (1) to continually lighten by denudation the exposed areas; and (2) to continually load by sedimentation the remote delta lands. The existing equilibrium thus disturbed could only be restored by the slow and continued upheaval of the one, and by a corresponding subsidence of the other, thus giving a cumula-

tive reaction, aiding the inaugurating cause. The geology of both continents confirms this.

The existence and permanence of this belt of cyclonic activity about the earth in latitude 50°–60° north is therefore not only a deduction of the writer, but also a geologically recorded fact, to which record the writer has the honor of directing attention.

That "Hz" should consider these facts unique and startling is to be regretted; but the writer's zeal would not lead him into undertaking the task of persuading any one to believe and accept these facts, who does not appear to grasp their meaning.

"Hz" would hardly deny that the Great Lakes occupy small depressions in the summit of the divide parting the drainage of the Arctic from that of the Gulf; or that their area is insignificant compared with that of the great belt traversed by the storm centers crossing this continent. That these lakes have slight influences in locally diverting the path of cyclones is admitted, but that they are determining causes fixing such trajectory has not been proved.

The writer must disclaim any attempt to show that a diminution of air pressure would cause a pull, and he regrets that "Hz" should have ascribed such an idea to him. That a pull could thus be transmitted vertically through air is a view not likely to meet with approbation, and smacks somewhat of the whimseys of the man who attempted "to lift himself up by the boot straps."

Should the writer be mistaken in any of his views, or erroneous in his citation of facts or deductions therefrom, he will be pleased to be corrected, and to have proper demonstrations accompany adverse views; but he does not regard the dogmatic assertions of "Hz" as conclusive arguments proving his side of the case.

MARSDEN MANSON.

SAN FRANCISCO, CAL., JAN. 25, 1892.

MIRAGE ON A WALL.

TO THE EDITORS:—On February 10, a clear fresh winter day in Cambridge, I noticed a peculiar mirage-like reflection from the surface of a brick wall, which seems to be worth placing on record. The ground was generally snow-covered from a light fall of two days before, but the sunshine was strong enough by noon to melt the snow and ice on the streets. In the afternoon, about three o'clock, I happened to stand for a few moments talk-

ing with a friend at the northern corner of a long NNW-SSE brick wall, on which the rays of the descending sun fell almost at right angles and produced a strong warming. A man was walking away from us at a distance of a hundred feet or so, and the reflection of his arm on the surface of the wall caught my eye. On looking closely, I found that when my eye approached within about an inch of the plane of the wall, the further extension of the wall disappeared, and was replaced by a reflection of distant objects a little to the west of its line. If a man happened to walk along by the wall within a foot of its surface, I could catch the reflection of his arm and side next to the wall by moving so as to bring my eye into proper position near the reflecting plane. The reflection repeated all the familiar forms seen over the surface of the sea, when cold winds blow from the land over its warmer waters. In the case of the wall, the mirage was evidently produced on the surface of a film of warm air close to the heated bricks. The plane of reflection was vertical, because the heating surface was vertical; but the principle of the thing differed in no essential way from that of the ordinary mirage of our sea-shore. Effects of this kind must be common, for on the day in question, all the conditions were such as might easily occur again. Is such a mirage generally known to our readers? W. M. Davis.

Harvard College, Feb. 11, 1892.

CURRENT NOTES.

A Request for Cloud Pictures.—The International Meteorological Conference, which met at Munich last year, decided to publish a colored Cloud Atlas representing the typical cloud forms according to the nomenclature of Hildebrandsson and Abercromby. The committee appointed to carry out the project, request the loan of colored drawings or paintings made from nature, in order that the most suitable may be reproduced in the Atlas. Such cloud studies may be sent for inspection to the American member of the commission, A. Lawrence Rotch, Blue Hill Observatory, Readville, Mass., and will be returned in good condition to the lenders.

The Current off Morant Cays, Jamaica.—A recent report from Capt. Reynholds, of the Norwegian Bark. "Hövding,"

calls attention to a strong northerly current experienced off Morant Cays. He states that at 8 P. M., on January 9, he fixed his course (after reliable chronometer observation at 4 P. M.) at W one-half S, to pass eight miles to the southward of the Cays. A sharp lookout was kept during the night but to his surprise the cays when sighted bore S by E, three miles distant. The longitude agreed with the distance run during the night, but instead of passing eight miles to the southward, as intended, there was an error of fifteen miles in latitude, due to a strong northerly current.—*Publications of Hydrographic Office.*

METEOROLOGY IN THE PUBLIC SCHOOLS OF BOSTON.—Mr. J. W. Smith, observer in charge of the Boston office of the United States Weather Bureau, recently addressed the masters of the high and grammar schools in that city on the subject of meteorology in the public schools. After giving an account of the establishment of the Signal Service weather work by a joint resolution of Congress, February 9, 1870, and of the methods employed in making observations and forecasts, and in preparing maps, Mr. Smith traced the gradnal growth of the service, the increase in number of stations, and the improvement in the forecasts, under Generals Meyer, Hazen and Greely, the successive Chief Signal Officers of the army. Since the transfer of the Weather Bureau to the Department of Agriculture, on July 1, 1891, the work under the direction of Prof. Harrington, the new Chief of the Bureau, has been still further improved and extended, and an effort is being made to render the results of greater benefit to farmers by a more wide-spread announcement of frosts and cold waves, and in many other ways.

In the first years of the weather work the general public looked upon the observer who attempted to forecast the weather as being gifted with almost supernatural powers, and a story is told of a weather-man's experience in a western town, which illustrated the popular feeling entertained in many quarters in those days. After the establishment of the station it happened that there came a long spell of unusually bad weather, which the people in the town believed to be due to the new weather prophet and his instruments. A committee of citizens was appointed to interview the observer, and the result was that the latter nearly had his life taken by the superstitious people. Even to-day some persons believe that there are weather machines which of themselves forecast the weather.

The real work of educating the general public must begin with their proper understanding of the weather maps, which present graphically the actual conditions of the weather over the whole country at the same moment of time. These observations are sent to Washington, where they are charted, and from Washington some of them are again telegraphed to such of the local offices as issue local charts. Boston was the first station to print a local map, and it also first used the shaded areas of precipitation and temperature changes. The Boston station issues more maps and other reports, covers more territory and sends more maps to the schools, than any other station in the United States. With the advantage of seeing the daily weather map before them every day, the pupils should be made familiar with the salient features of the maps, and should be able to predict, in a small way, the future conditions of weather. The district of New England is peculiarly exposed to great and sudden changes of weather, and the story is told of an old lady who, on her return from her first visit to New England, was asked what she thought of the climate there. "Climate," said she, "ha! they have nothing but climate there, and have weather only two or three days in the month."

The meaning of the various weather signs and the general facts of atmospheric pressure should be clearly understood, and in order to do this the facts of the composition, evolution and offices of the atmosphere must be known. The correlations of areas of high and low pressure with the circulation of the winds, with the weather and with the temperature, are essentials to a proper understanding of weather conditions, as also the direction and rate of movement of such areas, for on this the question of forecasting largely depends. The theory of radiant energy, the effect of insolation, the changes from winter to summer, the distribution of temperature over the globe and the resulting distribution of pressure and flow of winds, are all necessary subjects in such a study. When this is learned, the pupil can be further taught something about the theory of the origin of the storms which traverse our country, and the development of tornadoes, thunderstorms, etc., in connection with them.

In conclusion Mr. Smith said, that the time has come when the study of meteorology should not be confined to a few colleges, but should be freely taught in the common schools throughout the land, until each scholar can intelligently read the weather map. R. De C. W.